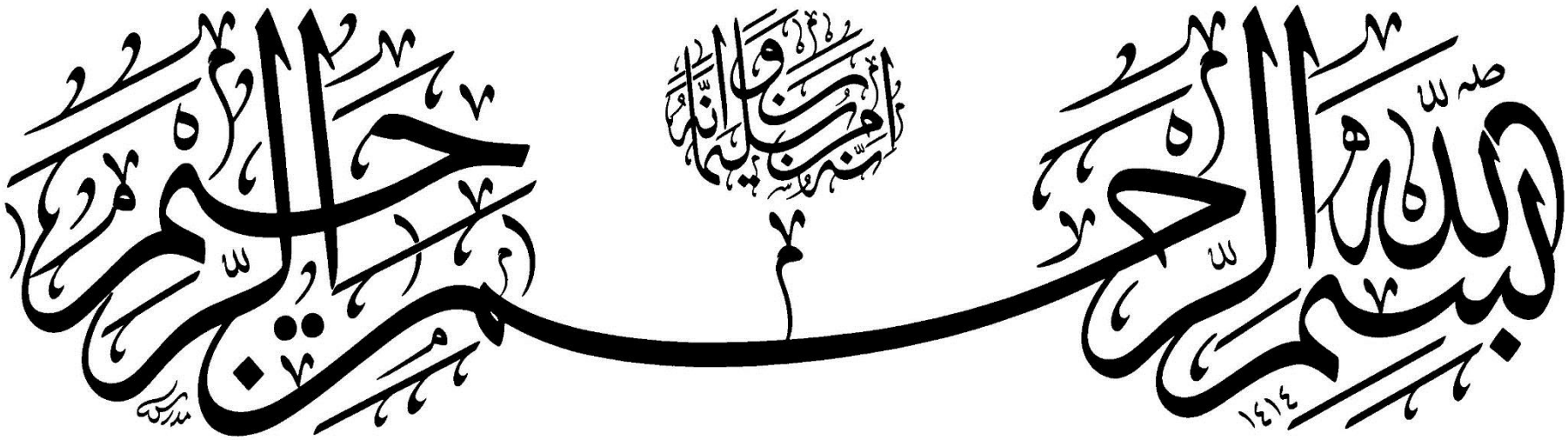
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Shiraz University
Faculty of Agriculture
Department of Horticultural Sciences

Seminar Topics:
Flooding stress in plants

By:
Hossein gholami
October 2014

Introduction

Segmentation based on Tolerance to waterlogging conditions

Anaerobic Microorganisms Are Active in Water-Saturated Soils

Roots Are Damaged in Anoxic Environments

Mechanism of Action

Damaged O_2 -Deficient Roots Injure Shoots

Submerged Organs Can Acquire O_2 through Specialized Structures

A review of research

References

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Introduction

Oxygen deficiency is typical of flooded or waterlogged soils.

Most tissues of higher plants cannot survive anaerobically, but some tissues, such as the embryo and coleoptiles from rice, can survive for weeks under anoxic conditions.

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depletion

When temperatures are low and plants are dormant, oxygen depletion is very slow and the consequences are relatively harmless. However, when temperatures are higher (greater than 20°C), oxygen consumption by plant roots, and soil fauna and microorganisms, can totally deplete the oxygen from the bulk of the soil water in as little as 24 hours.

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Segmentation based on Tolerance to waterlogging conditions

- Flooding-sensitive plants — *Pisum sativum*

- Flooding-tolerant plants — *Zea mays*

- Flooding- Adapted plants — *Oryza Sativa*

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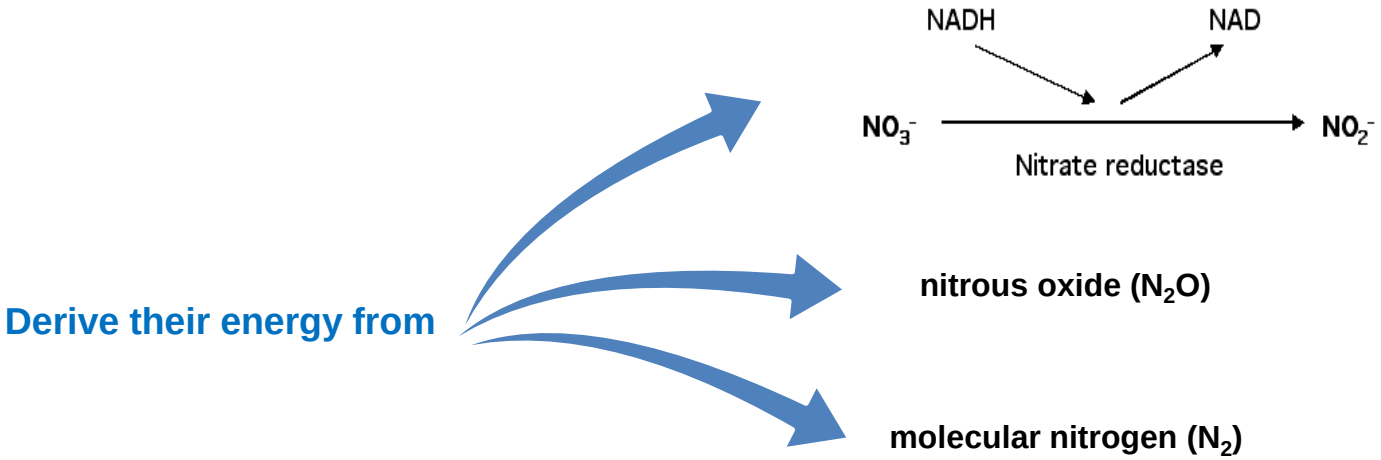
Anaerobic Microorganisms Are Active in Water-Saturated Soils

When soil is completely depleted of molecular O2, the function of soil microbes becomes significant for plant life and growth.



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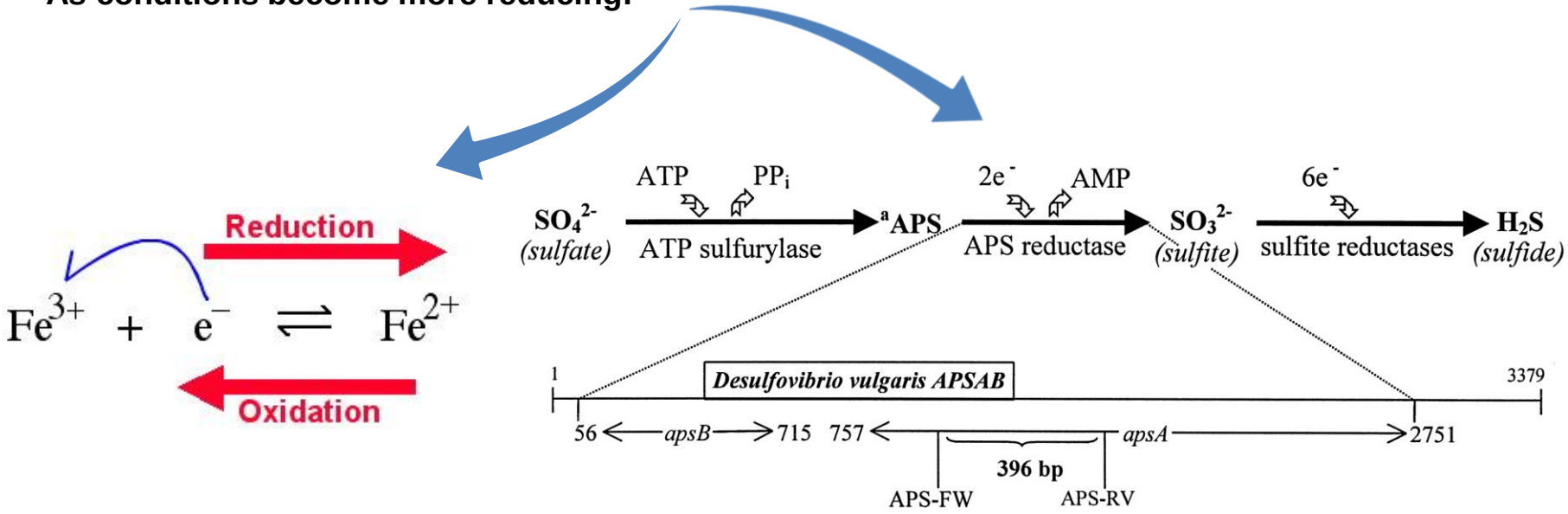
As conditions become more reducing:



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Roots Are Damaged in Anoxic Environments

- ✓ The **critical oxygen pressure** (**COP**) is the oxygen pressure at which the respiration rate is first slowed by O2 deficiency.
- ✓ When O2 concentrations are below the COP, the center of the root becomes anoxic (completely lacking oxygen) or hypoxic (partly deficient in oxygen).
- ✓ The COP for a maize root tip growing in a well stirred nutrient solution at 25°C, is about 0.20 atmosphere (20 kPa, or 20% O2 by volume), almost the concentration in ambient air.
- ✓ The COP is lower when respiration slows down at cooler temperatures.

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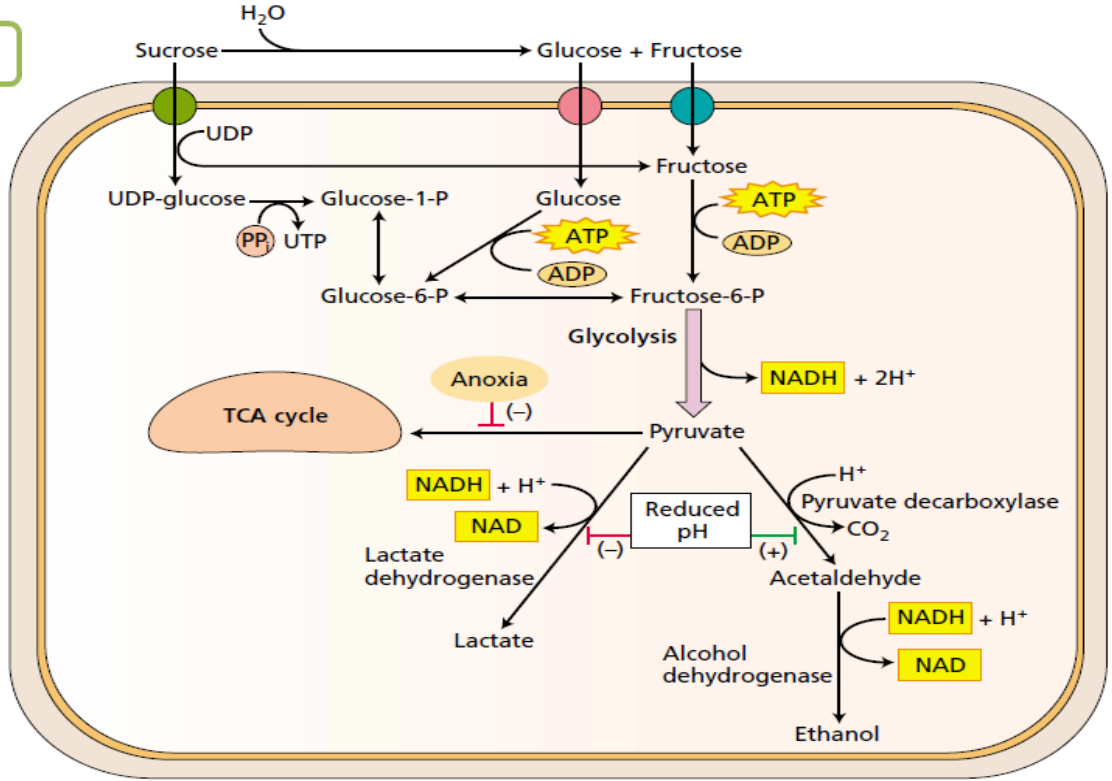
Mechanism of Action



Ref: Taiz & zeiger, 2006

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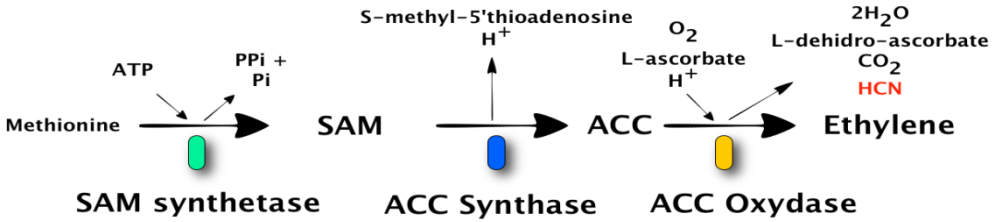
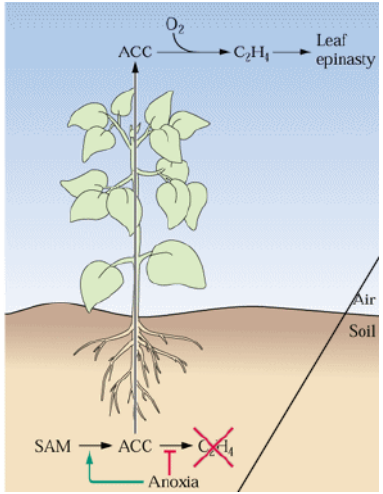
Damaged O_2-Deficient Roots Injure Shoots



Epinasty and The role of ACC

Hypoxia also accelerates production of the ethylene precursor **ACC** (**1-aminocyclopropane-1-carboxylic acid**) in roots. In tomato, ACC travels via the xylem sap to the shoot, where, in contact with oxygen, it is converted by ACC oxidase to ethylene. The upper (adaxial) surfaces of the leaf petioles of tomato and sunflower have ethylene-responsive cells that expand more rapidly when ethylene concentrations are high. This expansion results in epinasty, the downward growth of the leaves such that they appear to droop.



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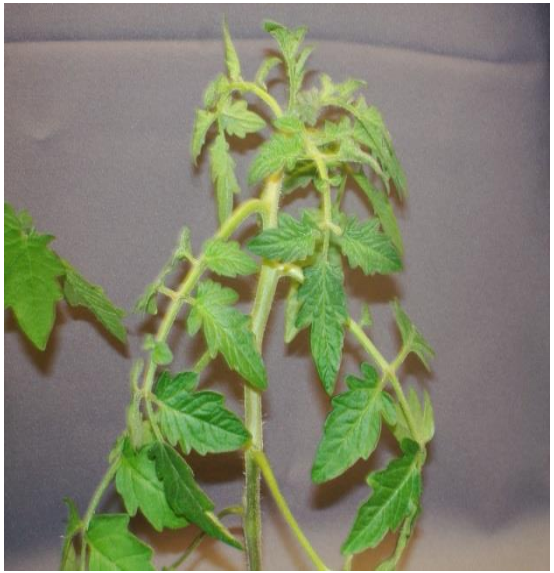
Epinasty in tomato



Ref: http://herbicidestewardship.utk.edu

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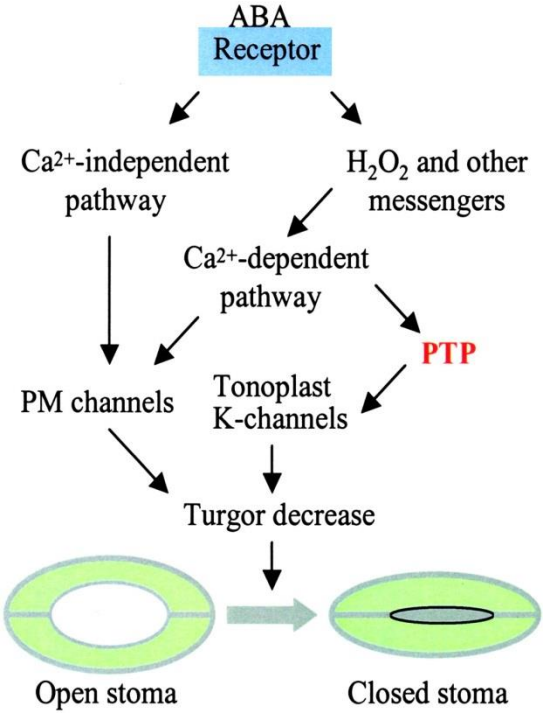
The role of ABA

In some species (e.g., pea and tomato), flooding induces stomatal closure apparently without detectable changes in leaf water potential. Oxygen shortage in roots, like water deficit or high concentrations of salts, can stimulate abscisic acid (ABA) production and movement of ABA to leaves. However, stomatal closure under these conditions can be attributed mostly to the additional production of ABA by the older, lower leaves. These leaves do wilt, and they export their ABA to the younger turgid leaves, leading to stomatal closure.



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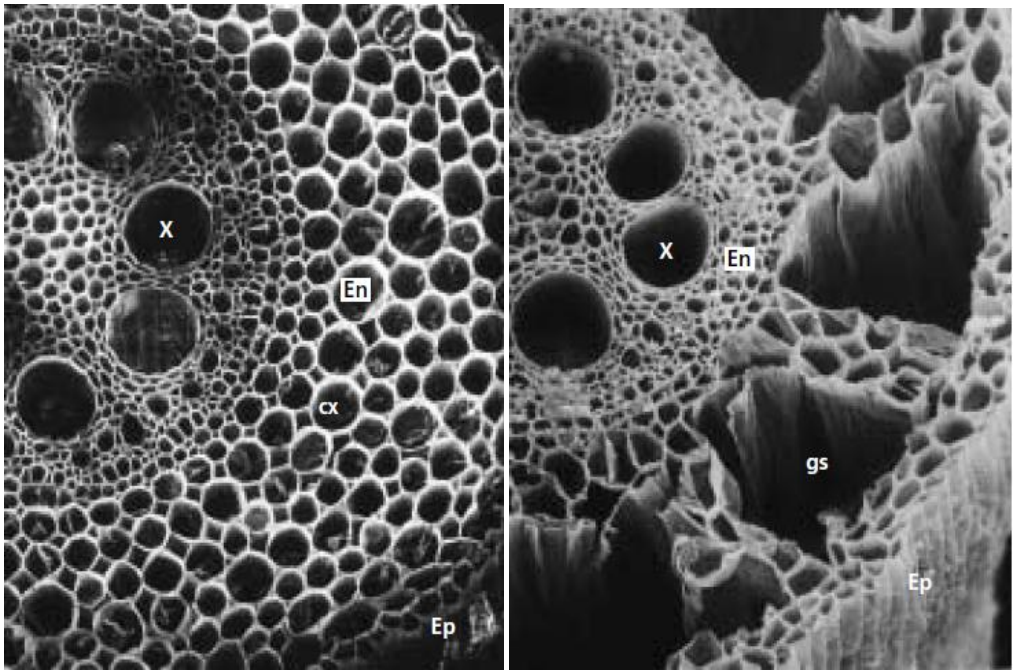
Submerged Organs Can Acquire O2 through Specialized Structures



In many wetland plants, exemplified by rice, cells are separated by prominent, gas-filled spaces, which form a tissue called **aerenchyma**.

Arise in cytosolic Ca^{+2} ⟶ cell death

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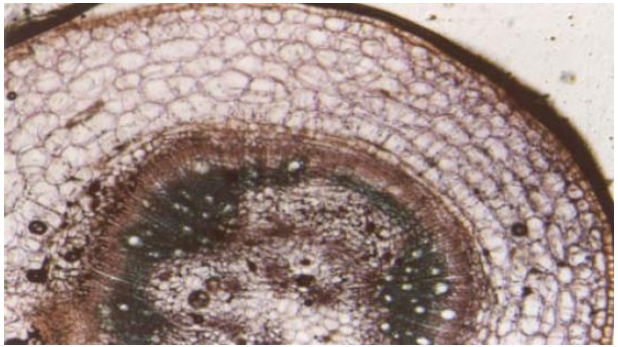
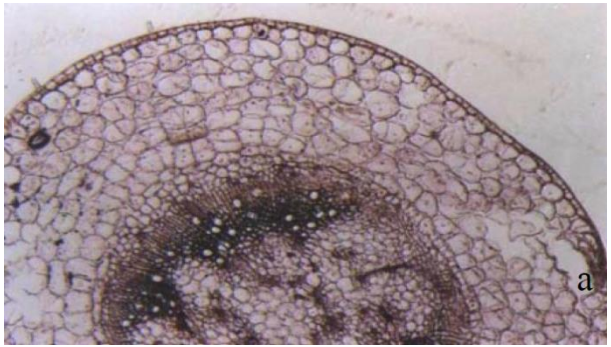
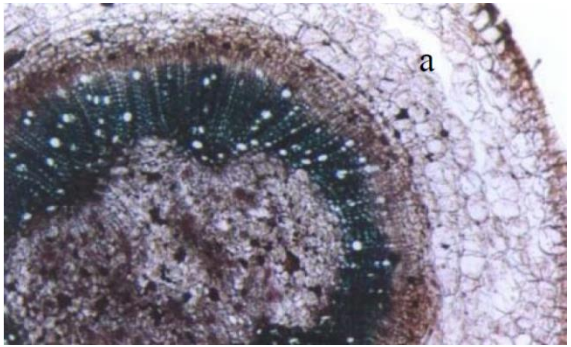
Cross-section of the stem of the pepper Under Flooding



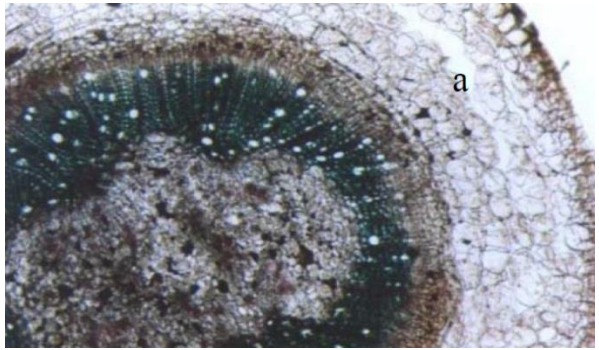
Control



Flooding for three days



Flooding for five days



Flooding for seven days

Ref: Malek-Ahmadi et al, 2005

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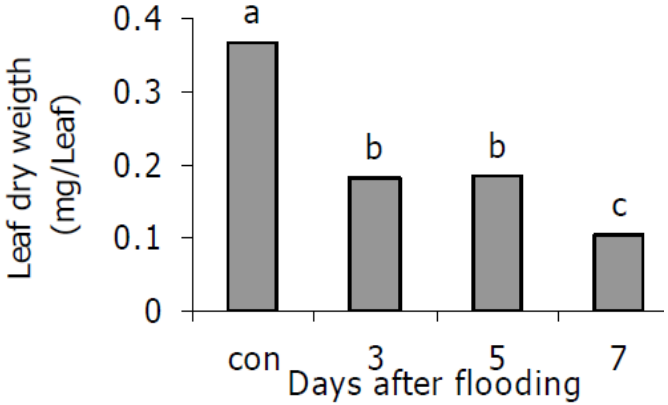

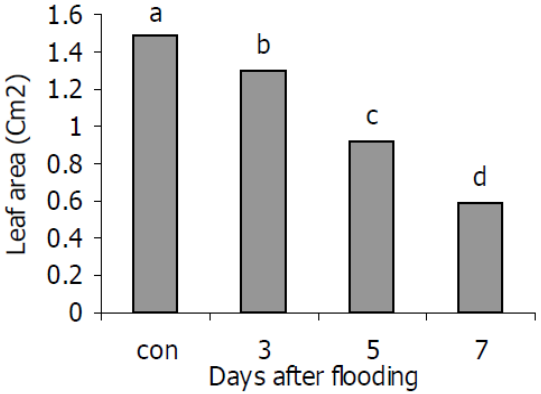

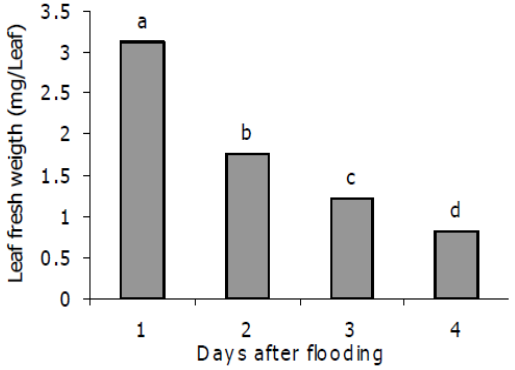

Ref: Malek-Ahmadi et al, 2005

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A review of research

Row	Researcher	Year	Paper / book Topics	Results
1	Najafi et al	2011	Effect of NaCl salinity and waterlogging, on the growth characteristics of forage corn under greenhouse conditions.	1.Reduction in plant height. 2.Reduction wet weight ratio of shoot to root. 3.Reduction in chlorophyll. 4.Reduction in shoot and root dry weight.
2	Grassini et al	2007	Responses to short-term waterlogging during grain filling in sunflower.	Reduction in leaf area of sunflower.
3	Ghobadi et al	2006	Evaluation of root growth, biomass, and grain yield in wheat genotypes under waterlogging stress at different growth stages.	Reduction in root length and dry matter after anthesis in Three genotypes of wheat.

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Row	Researcher	Year	Paper / book Topics	Results
4	Malek-Ahmadi et al	2005	Effects flooding on the induction of oxidative stress and concentration of elements in Pepper (*Capsicum annum* L.)	1. Increase in the concentrations of Ascorbic acid in leaf, Malondialdehyde (MDA) and Na^+. 2. Reduction the amount of Chlorophyll b, Carotenoids and K^+.
5	Dat et al	2004	Review: Sensing and signaling during plant flooding.	Reducction in leaf water potential.
6	Collaku & Harrison	2002	Losses in wheat due to waterlogging.	Reducction of Weight in grain of wheat.

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Row	Researcher	Year	Paper / book Topics	Results
7	Voesenek et al	2003	Interactions between plant hormones regulate submergence induced shoot elongation in the flooding tolerant Dicot *Rumex palustris*.	1. Reduction in uptake of water and minerals. 2. Reduction in photosynthetic capacity 3. Changes in hormonal balance. 4. destruction of Growth.
8	Aschi-Smiti et al	2003	Assessment of enzyme induction & aerenchyma formation as mechanisms for flooding tolerance in *Trifolium subterra neum park.*	
9	Huang & Wilkinson	2000	Plant Environment Interactions.	
10	Bacanamwo & Purcell	1999	Soybean root morphological and anatomical traits associated with acclimation to flooding.	

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Row	Researcher	Year	Paper / book Topics	Results
11	Lak zadeh et al	2002	Changes in 'Chamran' wheat tillers affected by waterlogging in various stages of development.	Reduction in the number of tillers of wheat.
12	Malik et al	2002	Short-term Waterlogging has long-term effects on the growth and physiology of wheat.	1. Reduction the growth of roots and shoots. 2. Reduction yield and yield components of wheat.
13	Stienger & Feller	1991	Nutrient accumulation and translocation in maturing plants grown on waterlogging soil.	Reduction in growth and yield of wheat.

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Row	Researcher	Year	Paper / book Topics	Results
14	Lizaso et al	1997	Maize shoot and root response to root zone saturation during vegetative	1. Reduction in leaf area 2. Reduction Severity of leaf photosynthesis 3. Early senescence of leave
15	Reyes et al	1997	Temperature and oxygen effects in soil on nutrient uptake in jojoba seedlings.	Reduction the rate of nutrient uptake.
16	Letey et al	1962	The influence of soil oxygen on growth and mineral concentrations of barley.	
17	Marshner	1995	Mineral Nutrient of Higher Plants.	1. Reduction shoot growth. 2. Premature senescence of leaves, especially the lower leaves. 3. Wilting and leaf rolling down the types of grasses sensetive Flooding.

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Row	Researcher	Year	Paper / book Topics	Results
18	Marshner	1995	Mineral Nutrient of Higher Plants.	Reduction Root permeability to water
19	Janes	1974	The effect of variations in root environment on root growth and resistance to flow of water in intact plants.	
20	Gardner et al	1993	Less Waterlogging damage with long season wheat.	Reduction in the number of seed per spike of wheat
21	Trought & Drew	1980	The development of waterlogging damage in young wheat plants in anaerobic solution cultures.	Flooding for four to eight days: 1. Reduction shoot growth. 2. Stopping root growth completely.

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Row	Researcher	Year	Paper / book Topics	Results
22	Hiron et al	1973	The role of endogenous abscisic acid in the response of plants to stress.	Disorder in Hormonal Balance with Effect on root metabolism
23	Kawase	1972	Effect of flooding on ethylene concentration in horticultural plants.	
24	Burrows et al	1969	Effects of flooding the root system of sunflower plants on the cytokinin content of the xylem sap.	
25	Philips	1964	Root-shoot hormone reaction II. Changes in endogenous auxin concentrations produced by flooding of the root system in *Helianthus annuus*.	

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Row	Researcher	Year	Paper / book Topics	Results
26	Yu et al	1969	Survival of plants under prolonged flooded conditions.	Flooding for two to four weeks: Slowing down the growth rate and dry weight in barley, maize, sunflower, tomato and wheat.

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